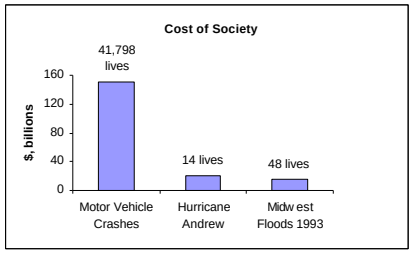
INTELLIGENT TRANSPORTATION SYSTEMS (ITS) ENHANCE SAFETY

SAFETY TODAY:

In 1995

- 9 million motor vehicle crashes
- 3 million injured
- 41,798 Americans killed

Motor vehicle crashes are the leading cause of death for persons age 5-27



While cancer and heart disease kill more people, victims of motor vehicle crashes tend to be younger. As a result, the lost years of productive life due to car crashes equals that from cancer or heart disease.

As many people die in motor vehicle crashes each year as live in Muskegon, Michigan or Charlottesville, Virginia

Cost of society: $150 billion each year (*By comparison, Hurricane Andrew Cost $0 billion)*

WHAT HAS BEEN DONE?

Traditional focus has been **protecting** vehicle occupants:

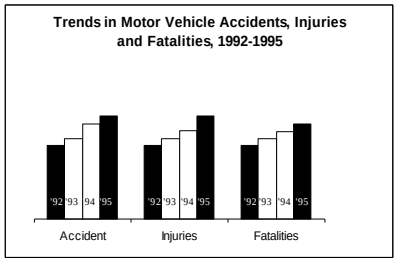
- Seatbelts save 10,000 lives each year and reduce fatalities and serious injuries by 50-70 percent
- Airbags, installed in one quarter of the cars on the road, save 500 lives each year
- Bumper and side-impact beam standards lessen the blow all together

Now the focus is moving toward **preventing** accidents all together:

If we can prevent the crash from ever occurring, motor fatalities, injuries, property damage, and travel delays will not occur.

- Center-mounted tail lights
- Anti-lock brakes
- Day-time running lights
- Drinking age limits

Despite these efforts, fatalities, Injuries and accidents are too high. A new approach is needed to improve safety while allowing for the faster, smoother travel . . .



THE NEXT STEP: INTELLIGENT TRANSPORTATION

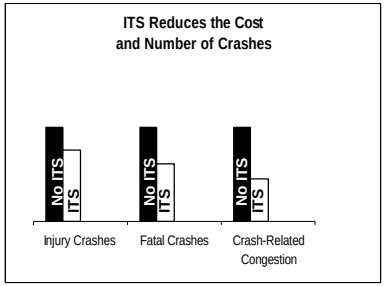
Preventing accidents requires enhancing drivers' performance. Fortunately, a new set of sensing and communication technologies have emerged that can do this. We use the umbrella term Intelligent Transportation System to refer to this next step.

ITS SAFETY APPLICATIONS:

- ***Crash Warning Systems -*** Vehicle warns driver about collision hazards, stopped or slowing vehicles ahead, tailgating, running off the road, or vehicles in the "blind-spot". This gives the driver more time to respond or to avoid dangerous action.
- ***Automated Travel Management -*** Traffic flow is enhanced using ramp metering, signal timing and lane control. Driver also receives information about the best route to take, This reduces congestion and results in safer driving conditions. Some of these technologies can improve our response to an accident, for example:
  - ***Emergency Response Systems -*** Police, Fire, and ambulance personnel respond to emergencies sooner. Traffic signals turn red, allowing emergency vehicles to pass through quickly, saving precious seconds in delivering medical care. Also, the accident is cleared from the road sooner, decreasing vehicle delays and congestion.
  - ***Automatic Vehicle Locator -*** Transit operators detect medical emergencies and crimes on buses and trains and also identify exact location of the troubled vehicle. This deters crime in transit systems, and improves personal security.
- ***Video Enforcement -*** Video cameras detect speeding and drivers running red lights. Signs notify driver that a violation has been detected. This provides a strong incentive for drivers to obey traffic laws and avoid dangerous driving.
- ***Vision Enhancement -*** Improves driver's vision of roadways at night and during inclement weather.

BENEFITS OF INTELLIGENT TRANSPORTATION:

- 34 percent reduction in fatal crashes
- 24 percent reduction in injury crashes
- Just 3 Crash Avoidance Systems alone could **eliminate more than 49,000 fatalities,** returning motor vehicle fatalities to their **lowest point since 1960,** prevent 1.2 million accidents, and **save $26 billion** each year. (By comparison, seatbelts and airbags save 10,500 lives per year.)
- 50-60 percent reduction in accident- related traffic delays



DEMONSTRATED INTELLIGENT TRANSPORTATION SYSTEMS (ITS) SAFETY BENEFITS

ITS REDUCES CRASHES:

Advanced Traveler Information System (ATIS)

Colorado: The Dynamic Truck Speed Warning System for Long Downgrades, installed on I-70 near of the Eisenhower Tunnel West of Denver, warns drivers of safe truck speed at the start of the downgrade based on the truck's measured weight. Observers report that trucks being instructed to slow frequently apply their brakes immediately.

Florida: The TravTek project examined the safety aspects of an in-vehicle navigation device that used a moving map display as well as voice directions. Compared to control conditions of paper maps and road signs, use of both visual and voice displays yielded lower time stress, visual effort, and psychological stress. TravTek users also perceived that they were safer.

Florida: The TravTek project used a simulation approach to estimate safety impact. Results indicated an overall reduction in crash risk up to 4 percent for motorists using navigation devices, due to improved wrong turn performance and the tendency of the navigation system to route travelers to higher class (normally safer) facilities.

Advanced Traffic Management System (ATIS)

Washington, Illinois, New York, Virginia, Minnesota, and California: Collisions on freeway systems under freeway management have been reduced between 15 percent and 50 percent, with ramp metering being a significant positive factor. While some other freeway improvements were implemented during the study periods, the combination of geometric, vehicle, and operational procedures showed significant reductions in collision rate.

Maryland: Recent evaluations of freeway management systems without ramp meters also yielded crash reductions. The CHART system in Maryland reported a 5 percent reduction in secondary crashes.

Texas: The TRANSGUIDE system us San Antonio, Texas, another freeway management system that does not use ramp meters, reported a 30 percent reduction in secondary crashes and a 35 percent reduction in total crashes

Los Angeles: Initial tests of photo enforcement at highway-railroad intersections in Los Angeles have yielded positive results, with a 92 percent decrease in violation rate.

Japan: Two types of speed-sensitive traffic signal control devices recently installed in Japan have reduced crashes at equipped intersections by 25 percent - 30 percent and pedestrian involvement by 85 percent.

London: Although controversial, video enforcement for speed and red-light violation are effective. Installations in London have reduced crashes 20 percent - 80 percent and serious injuries and fatalities by about 50 percent.

Commercial Vehicle Operations (CVO)

Oregon: An early information network in Oregon enabled an increase of 90 percent in number of weighings and 428 percent in number of safety inspections between 1980 and 1989 while staff increased by only 23 percent. While these measures are not directly of desired outcomes, the link between inspections and reductions in crashes is intuitive.

National: ITS implementation is expected to improve the safety record of motor carriers. Evidence of future success is indicated by ongoing motor carrier safety programs including the Motor Carrier Safety Assistance Program (MCSAP) and safety audits. The benefit/cost ratio of these programs has been estimated as 2.5 while yielding a reduction of 2,500, 3,500 collisions annually.

ITS REDUCES FATALITIES:

Advanced Traveler Information System (ATIS)

Oklahoma: Automatic vehicle location (AVL) in conjunction with computer-aided dispatching (CAD) and navigation systems are being installed in fire, police, and emergency vehicles. A crash in Muskogee County, Oklahoma, involving a car and a school bus, results in the need for medical attention. The fog that contributed to the collision would have also delayed an ambulance and made location of the collision difficult from a helicopter. However, the helicopter, equipped with a Global Positioning System (GPS) receiver, located the crash scene using location information provided by a Highway Patrol office on the scene using a handheld GPS. The helicopter as then able to complete the rescue.

Illinois: In Schamburg, Illinois, the AVL system installed by the police department has been reported to enable dispatch of backup to officers who failed to report location information and dispatch of assistance to an incapacitated officer.

Advanced Traffic Management System (ATMS)

National: According to statistical analysis based on data from the Fatal Accident Reporting System, reduction of incident notification times on rural highways from the current average of 9.6 minutes to 4.4 minutes, corresponding to mayday devices working properly in 60 percent of rural crashes, would result in a reduction in fatalities of 7 percent annually, or a national total of 1727.

National According to statistical analysis based on data from the Fatal Accident Reporting System, reduction of incident notification times on urban interstates from the current average of 5.2 minutes ti 2 minutes would result in a reduction in fatalities of 15 percent, or a national Total of 356 lives annually if all urban interstates nationwide were under such a program.

Germany: In field tests of an on-board crash notification system, calls generated to simulate emergency situations have shown a decrease in time for medical help to arrive from 14 minutes to 8 minutes for urban crashes and from 21 minutes for out-of-town crashes. The 43 percent increase in the chance of survival for an occupant involved in the crash.

Commercial Vehicle Operations

National: Analysis using empirical data to estimate the impact of CVO implementation on fatal involvements found a potential reduction of 14 percent to 32 percent. The analysis considered experience reported relating total miles traveled, percentage of rural travel, and inspection practices to fatality rate.

Integrated Systems

Texas: The *San Antonio TransGuide* facility opened in the summer of 1995. The value of an integrated facility was demonstrated in the week before the center opened when an industrial plant fire erupted within view of freeway video surveillance. Based on the visibility afforded at TransGuide, the fire was accessed and found more effectively possibly saving the lives of several firefights.

Safety Benefits from ITS Services

The Problem

Crashes on US roadways extract a great toll on American lives. In 1995, 37,221 fatal crashes caused 41,798 deaths. Additionally, 2.335,000 injury crashes injured 3,613,000 people. In addition to these personal costs, crashes in 1994 were estimated to involve 3.8 million uninjured passengers and damage 27 million vehicles. The National Highway Traffic Safety Administration (NHTSA) estimated the total cost of motor vehicle crashes in 1994 to be $150.5 billion.

U.S. Department of Transportation (USDOT) collects statistics on fatal and non-fatal crashes. The relative size of the crash problem can be described from a number of perspectives, which give indications of methods to approach improving safety. As shown in Figure 1 and Figure 2, nearly three fourths of injury crashes occur in urban areas, while over half of fatal crshes occurs in rural areas. Figure 3 demonstrates that the relative severity of the crash problem on different classes of highway depends on the metric used. While lower grade roads have a larger portion of fatal crashes and higher fatality rates per vehicle-mile traveled.

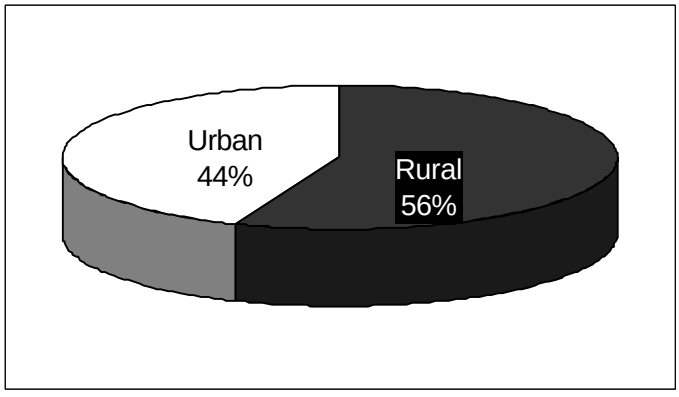


Figure 1 - Total Fatal Crashes

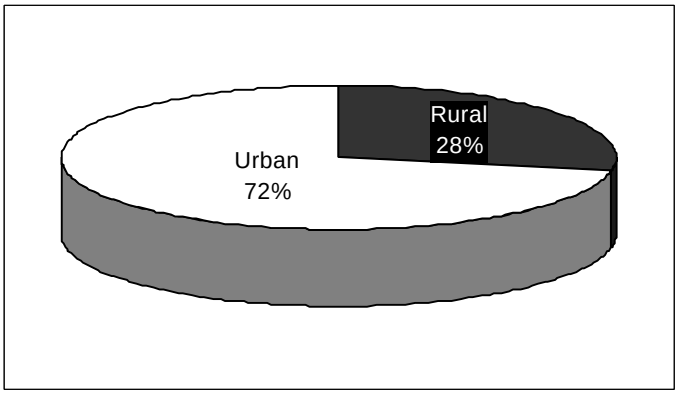


Figure 2 - Total Injury Crashes

Higher grade roads experience more fatal crashes per mile of roadway. Therefore, infrastructure countermeasures would be appropriate on higher grade roads while in-vehicle devices may assist more for travel on lower grade roads.

ITS Solutions

Intelligent Transportation Systems (ITS) offer tools to address transportation safety on several fronts, including improving control of the vehicle, mitigating circumstances that contribute to crashes, and responding more quickly to crashes that do occur. By applying appropriate tools to specific problems. ITS offer the potential to significantly reduce the number and severity of crashes.

Under the leadership of NHTSA, the National Automated Highway System Consortium (NAHSC), and the automotive industry, improved vehicle control devices are being developed. NHTSA estimates that the three most imminent in-vehicle crash avoidance systems (CAS) alone could reduce the number of annual crashes by 17% out of the 6.4 million nationwide. These countermeasures address

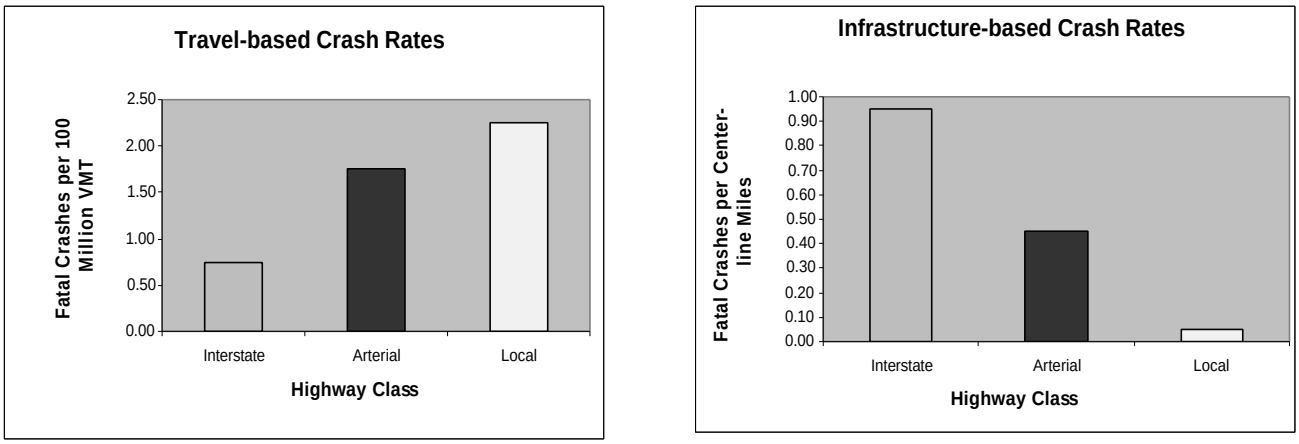


Figure 3 - Comparison of Crash Rates

rear-end crashes, roadway departures, and lane change/merge crashes, which collectively represent half of the highway crashes in the U.S., by assisting the driver in the driving task.

Improved traffic control and enforcement techniques provide a second approach to reducing crash occurrence and consequence. Freeway management, including such techniques as incident management, ramp metering, and lane control, as well as advanced surface street traffic signal systems improve the flow of traffic to reduce crash occurences. In locations with specific crash problems such as highway-rail intersections and certain arterial intersections or roadways, more aggressive automated enforcement techniques such as grade crossing compliance, video speed enforcement, and video signal enforcement systems can greatly reduce safety violations. Automation aids to commercial vehicle regulation such as the Motor Carrier Safety Assistance Program (MCSAP) and automation assistant in inspections improve safety enforcement in an industry with skilled professional drivers operating vehicles with potential for significant loss to property and life.

Techniques to make the driver more aware of the roadway environment also assist in the driving task. Navigation devices including route guidance assist in route finding, which is particularly valuable for unfamiliar drivers. Roadway condition information provided through variable message signs or in-vehicle devices allows drivers to select alternate paths or Modes to improve safety in addition to decreasing travel time.

Quicker response for victims of crashes improves medical service, decreasing the chances that a fatality will result. Quicker removal of the crash from the travel way returns flow to normal conditions, decreasing the probability of secondary crashes. Automatic collision notification devices, rural mayday systems, and incident notification systems alert emergency service providers more quickly to the occurrence of a crash. These systems can reduce the time between crash and arrival of injured travels at emergency medical care. A reduction of 10 minutes in this time interval can improve the chances that an injured traveler will survive by over 10%. When incidents occur on congested roadways, crash rates triple in the congestion approaching the incident. Incident management systems reduce the duration of the incident-related congestion, reducing the duration of related increase in crash rate.

Estimating Benefits

To estimate benefits, expected crash reduction rates were applied to crash problem sizes tabulated by NHTSA in Traffic Safety Facts 1995. Each ITS countermeasure applies only to certain crash situations. For example, motor carrier enforcement improvements apply only to the subset of crashes involving motor carriers. The expected crash reduction rates for infrastructure countermeasures were taken from a combination of field experience and analytical

Prediction. The expected crash reduction rates for in-vehicle crash reduction were take from NHTSA publications.

The following tables summarize potential crash reduction benefits from ITS. Table 1 summarizes anticipated results from full implementation of infrastructure ITS countermeasures. Based on the subset of infrastructure-supported ITS services. 10% of injury crashes and 27% of fatal crashes could be avoided. Table 2 summarizes anticipated results from implementation of near-term, in-vehicle crash avoidance devices. The reduction in total number of crashes of 17% from full deployment of in-vehicle countermeasures predicted by NHTSA analysis includes a reduction of 16% in injury crashes and 9% of fatal crashes. Table 3 estimates total crash reduction benefits of ITS. Assuming that the target crashes for infra-structure and in-vehicle countermeasures overlap so that crash reduction totals are not fully additive, full deployment of ITS counter-measures could result in a reduction of 24% in injury crashes and 34% in fatal crashes.

The tabulated crash reduction benefits are estimates. The impact in crash reduction for targeted crashes is based on limited field experience, laboratory analysis, and simulation. The number of crashes occurring on impacted roadways and the number of targeted crashes occurring are taken from USDOT publications. As an example, consider the impact of grade crossing compliance devices on the number of fatal crashes. This countermeasure is applicable to roadways that are not grade separated from rail lines, which includes all roadways except freeways. On non-freeways, a total of 31,966 fatal crashes occurred in 1995. Of that total, 1.96% (626) fatal crashes occurred at highway-Rail grade crossing. In limited trials, grade crossing compliance devices have cut the violation rate by 90%. Making the assumption that the reduction in violation rate at grade crossings with active warning devices is the same as the reduction of fatal crashes at grade crossings, 90% of the 626 fatal crashes (for a total of 593 fatal crashes) at grade crossings can be expected to be avoided. The avoidance of 563 fatal crashes represents a reduction of 1.51% in the number of fatal crashes in the United States.

The significant reduction in crashes from ITS countermeasures can be brought about only by the combination of ITS services, as represented in Figure 4. The implementation of these integrated services requires contribution from government as well as product developers and infrastructure providers.

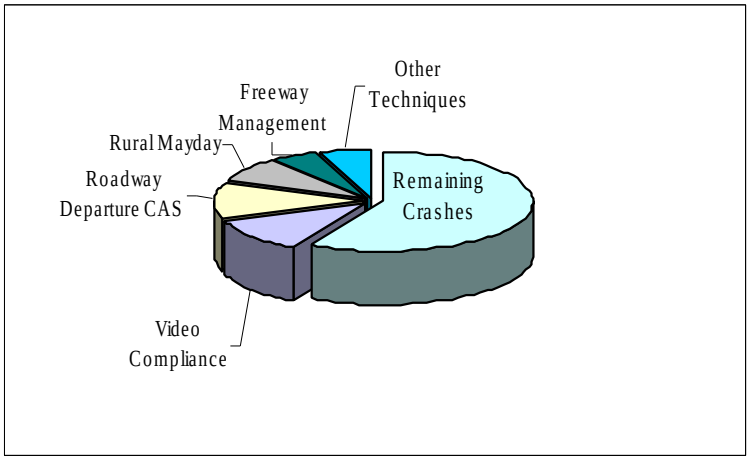


Figure 4 - Contribution to Fatal Crash Reduct by ITS Countermeasure

Injury Crashes

Countermeasure	Impacted Roadway	Roadway Crash Size	Target Crash Size	% Crash Impact	Crashes Avoided	% Crash Reduction
Freeway Management	Urban Freeway	253,026	253,026	30%	75,908	3.25%
Video Compliance	All	2,334,623	583,656	20%	116,731	5.00%
Grade Crossing Compliance	Non-Freeway	2,028,738	1,837	90%	1,653	0.07%
Route Guidance	Urban Arterials	894,940	894,940	3%	26,848	1.15%
MCSAP/Inspections	All	2,334,623	97,000	22%	21,572	0.92%
Rural Mayday	All Rural	664,283	664,283	0%	0	0.00%
Total					242,712	10%

Fatal Crashes

Countermeasure	Impacted Roadway	Roadway Crash Size	Target Crash Size	% Crash Impact	Crashes Avoided	% Crash Reduction
Freeway Management	Urban Freeway	3,033	3,033	40%	1,213	3.26%
Video Compliance	All	37,221	9,305	50%	4,653	12.50%
Grade Crossing Compliance	Non-Freeway	31,966	626	90%	563	1.21%
Route Guidance	Urban Arterials	8,845	8,845	3%	265	0.71%
MCSAP/Inspections	All	37,221	3,858	22%	858	2.31%
Rural Mayday	All Rural	20,779	20,779	12%	2493	6.70%
Total					10,045	27%

Table 1 - Infratructure ITS Benefits Summary

Injury Crashes

Countermeasure	Impacted Roadway	Roadway Crash Size	Target Crash Size	% Crash Impact	Crashes Avoided	% Crash Reduction
Rear End CAS	All	2,334,623	580,000	48%	278,400	11.92%
Lane Change/Merge CAS	All	2,334,623	12,500	37%	4,625	0.20%
Roadway Departure CAS	All	2,334,623	337,500	24%	81,000	3.47%
Total		2,334,623	930,000		364,025	16%

Fatal Crashes

Countermeasure	Impacted Roadway	Roadway Crash Size	Target Crash Size	% Crash Impact	Crashes Avoided	% Crash Reduction
Rear End CAS	All	37,221	1,055	48%	506	1.36%
Lane Change/Merge CAS	All	37,221	205	37%	76	0.20%
Roadway Departure CAS	All	37,221	12,118	24%	2,908	7.81%
Total		37,221	13,378		3,490	9%

Table 2 - In-Vehicle ITS Benefits Summary

Injury Crashes						
Countermeasure	**Impacted Roadway**	**Roadway Crash Size**	**Target Crash Size**	**% Crash Impact**	**Crashes Avoided**	**% Crash Reduction**
Freeway Management	Urban Freeway	253,026	253,056	30%	75,908	3.25%
Video Compliance	All	2,334,623	583,656	20%	116,731	5.00%
Grade Crossing Compliance	Non-Freeway	2,023,738	1,837	90%	1,653	0.07%
Route Guidance	Urban Arterials	894,940	894,940	3%	26,848	1.15%
MCSAP/Inspections	All	2,334,623	97,000	22%	21,572	0.92%
Rural Mayday	All Rural	664,283	664,283	0%	0	0.00%
Infrastructure Total					242,712	10.39%
Read End CAS	All	580,000	580,00	48%	278,400	11.92%
Lane Change/Merge CAS	All	12,500	12,500	37%	4,625	0.20%
Roadway Departure CAS	All	337,500	337,500	24%	81,000	3.47%
In-Vehicle Total					364,025	15.59%
Total					560,310	24%

Injury Crashes						
Countermeasure	**Impacted Roadway**	**Roadway Crash Size**	**Target Crash Size**	**% Crash Impact**	**Crashes Avoided**	**% Crash Reduction**
Freeway Management	Urban Freeway	3,033	3,033	40%	1,213	3.26%
Video Compliance	All	37,221	9,305	50%	4,653	12.50%
Grade Crossing Compliance	Non-Freeway	31,966	626	90%	563	1.51%
Route Guidance	Urban Arterials	8,845	8,845	3%	265	0.71%
MCSAP/Inspections	All	37,221	3,858	22%	858	2.31%
Rural Mayday	All Rural	20,779	20,779	12%	2493	6.70%
Infrastructure Total					10,045	26.99%
Read End CAS	All	37,221	1055	48%	506	1.36%
Lane Change/Merge CAS	All	37,221	205	37%	76	0.20%
Roadway Departure CAS	All	37,221	12,118	24%	2,908	7.81%
In-Vehicle Total					3,490	9.37%
Total					12,665	34%

Table 3 - ITS Benefits Summary

% Crash Impact Derivation Notes and References

Injury Crashes

1. The FHWA ramp metering document yields crash reduction numbers in range of 15% - 60%. The TransGuide initial reports claim a reduction of 35% in the overall number of crashes. Lacking detail of the distribution of reduction to fatal, injury, and property damage crashes, this analysis assumes about 30% reduction in each category.

2. Video signal enforcement has shown good promise, but only in limited use. The 20% crash impact number used comes from a single article in the Spring 1995 issue of Traffic Technology International reporting on successes in London. An estimate of speed and red-light violation related crashes of 25% is also used to estimate target crash size.

3. Grade crossing effectiveness is based on the reduction of violation rate in Southern California of 90% with video enforcement at grade crossings and is applied equally to fatal crashes.

4. Route guidance effectiveness is taken from TravTek and applied equally to fatal crashes.

5. MCSAP/Inspections effectiveness is taken from a study by Evanco on CVO safety aspects of ITS and a small contribution from the MCSAP program founded in Northwestern University study by Moses and Savage. The effectiveness rate is applied equally to fatal and injury crashes.

6. Rural Mayday effectiveness applies only after occurrence and would therefore not reduce the number of injury crashes. To the extent that the fatal crashes would become injury crashes, this number would increase by 0.3%.

7. The NHTSA paper presented results in terms of injuries and fatalities, rather than injury crashes and fatal crashes. The numbers were converted by a factor of 1/6 for injuries.

Fatal Crashes

1. Ramp metering document yield crash reduction numbers in the range of 15% - 60%. The TransGuide initial reports claim a reduction of 35% in overall number of crashes. Lacking detail of the distribution of reduction of fatal, injury, and property damage crashes, this analysis assumes about 30% reduction in each category. Evanco (Mitretek) predicts a reduction in fatalities of 16% with improved incident detection, yielding a rough estimate of 40% fatal crash reduction (1-70% - 16%*70*).

2. Video signal enforcement has shown good promise, but is only in limited use. The 50% crash impact number used comes from a single article in the Spring 1995 issue of Traffic Technology International reporting on successes London. An estimate of speed and red-light violation related crashes of 25% is also used to estimate target crash size.

3. Grade crossing effectiveness is based on the reduction of violation rate in Southern California of 90% with video enforcement at grade crossings and is applied equally to injuries and fatalities.

4. Route guidance effectiveness is taken from TravTek and applied equally to fatal crashes.

5. MCSAP/Inspections effectiveness is taken from a study by Evanco on CVO safety aspects of ITS and a small contribution from the MCSAP program found in a Northwestern University study by Moses and Savage. The effectiveness rate is applied equally to fatal and injury crashes.

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